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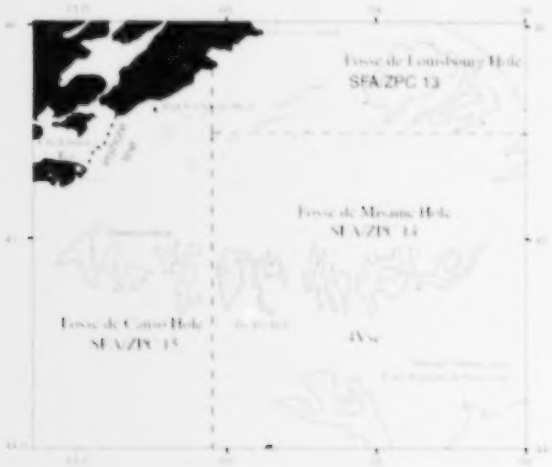
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2006/044

NORTHERN SHRIMP ON THE EASTERN SCOTIAN SHELF (SFA 13-15)

(J. Domm 2006)



Context

Advice on the status of the eastern Scotian Shelf shrimp stock is requested by DFO Fisheries Management and industry to help in determining a TAC which is consistent with the management plan. Annual assessments are required because of the variable nature of recruitment to the population and the fishery, as well as fluctuations of shrimp sizes available for harvest. The resource is near the southern limit of the species' distribution where it is thought to be more vulnerable to significant declines, as has been observed in the adjacent Gulf of Maine stock. The current report provides information and advice for management of the 2007 fishery.

The trawl fishery on the Scotian Shelf occurs during summer in the deep offshore shrimp "holes", and on an inshore area near the Bad Neighbor Shoal. The main management tools are limits on the number of licenses and size of vessels used, minimum codend mesh size (40mm), use of a Nordmore separator grate, and a Total Allowable Catch (TAC). This fleet (about 20 active trawlers) is divided into two sectors, a midshore sector consisting of about 7 active vessels 65-100' Length Over all (LOA) based in New Brunswick on the Gulf of St. Lawrence side, and an inshore sector consisting of vessels mainly <65' LOA based on the Atlantic coast of Nova Scotia. A trap fishery, consisting of 6 active vessels, restricted to Chedabucto Bay. All licenses except traps operate under ITQs.

Canada

SUMMARY

- The TACs in 2005 and 2006 was not caught mainly due to marketing conditions, not resource availability.
- In 2006 more effort shifted to SFA 14 to take advantage of the large accumulated biomass there, resulting in a more even distribution of exploitation rates across areas.
- Fishers again experienced difficulty in avoiding small shrimp in 2006.
- Commercial catch rates (CPUEs) in 2006 were the highest on record due to the increased availability of the 2001 year-class.
- The DFO-industry survey index decreased again in 2006, but was still the third highest of the 12 year series. Most of the biomass remains concentrated in Survey Area 14 (Misaine).
- The spawning stock biomass of females also decreased in 2006, mainly because of slow growth and delayed sex change of the 2001 year-class, but it remains above average. It is expected to remain high or increase in 2007 as the 2001 year-class changes sex.
- The 2001 year-class continues to be strong in most areas. It currently makes up about half of the biomass which is a concern because of the unevenly distributed size/age structure.
- Total (10%) and female (14%) exploitation remain below average (12 and 16%, respectively).
- Biomass is expected to remain high as the 2001 year-class recruits to the female population in 2007. Counts should be more favourable than in the previous 2 years due to growth of the 2001 year-class. The high TACs of the last two years should be sustainable for at least one more year.
- The 2002-2005 year-classes are weaker than the 2001 year-class and biomass is expected to decrease as it dies off during 2008-2009. TAC reductions may be indicated after 2007.

BACKGROUND

Species Biology

The northern or pink shrimp, Pandalus borealis, is the only shrimp species of commercial importance in the Maritimes Region. Shrimp are crustaceans, and have a hard outer shell which they must periodically shed (molt) in order to grow. The females produce eggs once a year in the late summer-fall and carry them, attached to their abdomen, through the winter until the spring, when they hatch. Consequently, shrimp bear eggs, or are "ovigerous" for about 8 months of the year. Newly hatched shrimp spend 3 to 4 months as pelagic larvae, feeding near the surface. At the end of this period they move to the bottom and take up the life style of the adults. On the Scotian Shelf, the northern shrimp first matures as a male, at 2 years of age, and at age 4 it changes sex, to spend another 1 to 2 years as a female. Shrimp live 5 to 8 years, depending on conditions.

Shrimp concentrate in deep "holes" on the eastern Scotian Shelf, but nearshore concentrations along coastlines closest to the offshore populations were discovered by 1998. They prefer temperatures of 2 to 6 °C, and a soft, muddy bottom with a high organic content.

The Fishery

Landings (000s t)

Year	1999	2000	2001	2002	2003	2004	2005	2006
TAC	5.0	5.5	5.0	3.0	3.0	3.5	5.0	5.0
Landings	4.9	5.4	4.8	2.9	2.8	3.3	3.6	4.2

Landings projected to December 31, 2006.

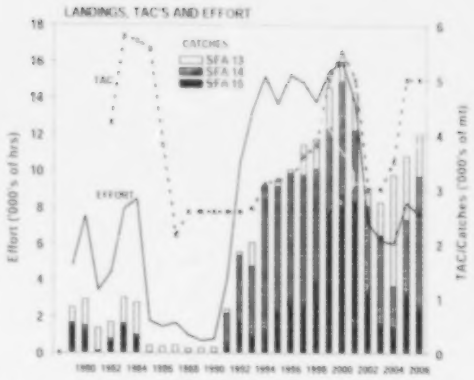


Figure 1. Landings, TACs, and Effort.

The fishery currently consists of 28 (18 active) inshore licenses mostly <65' LOA and 7 active mid-shore licenses 65-100' LOA. All mobile licenses have been under ITQs since 1998. A competitive trap fishery with 14 (6 active) licenses is restricted to Chedabucto Bay. The fishery operates under a 5-year management agreement (2007-2011) which, among other aspects, documents sharing agreements between fleet sectors.

The TAC has been caught most years since individual SFA quotas were combined into a single TAC in 1994 with minor shortfalls associated with logistic problems (Figure 1). More substantial shortfalls occurred in 2005-2006 due mainly to market conditions, not resource availability. During 2005/2006, effort and catches in the trap fishery off Canso (SFA 15) were low due to poor market conditions, however catches per trap haul are comparable to previous years. The fishery continues to prefer access to all areas under one global TAC (i.e. no individual SFA quotas) because of the flexibility this offers in obtaining favourable combinations of good catch rates and counts (shrimp sizes).

The **seasonal pattern** of the fishery has changed little over the years (Figure 2). Most shrimp are caught during April-June. Effort tends to decrease during summer due to market conditions. Catches during the August-April ovigerous (egg-bearing) period tend to be proportionally larger in years of high TACs as fishers take longer to catch higher quotas. This was again the case in 2006 when 26% percent of the catch was taken during the ovigerous period. This is not currently considered to be a problem due to the large spawning stock biomass (SSB), but it could potentially contribute to other factors decreasing population fecundity, such as decreasing size at sex change and female sizes.

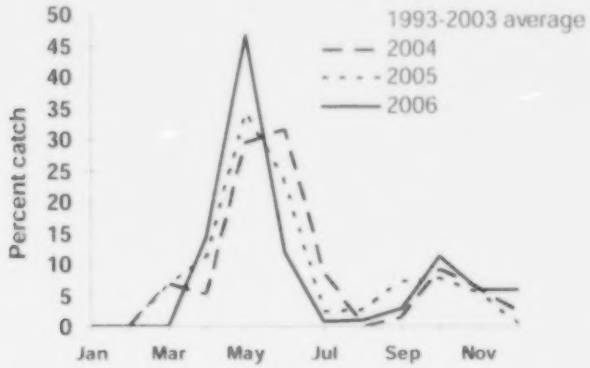


Figure 2. Seasonal patterns in the Scotian Shelf shrimp fishery.

The **spatial pattern** of the fishery has changed significantly over the years. Prior to 1999, most of the effort and catch was in the Misaine Hole (SFA 14). In 1998, fishing began along the southern Cape Breton shore (Bad Neighbor Shoal), with 44% of the catch taken in this area during 1999. This has since decreased and only amounted to about 11% in 2006. In 2004, a large part of the TAC was taken in SFA 13. In 2005/2006, effort shifted to SFA 14 to take advantage of the large accumulated biomass there, resulting in a more even distribution of exploitation rates across areas. During 2006, most (60%) of the catch again came from SFA 14 although its rate of exploitation at about 13% is moderate due to the high accumulated biomass. Spatial and temporal changes in the distribution of fishing effort, catch rates (Catch Per Unit Effort (CPUE)), availability to the fishing gear, and the resource itself are complex. Consequently, CPUE is not always representative of overall abundance.

Decreases in the **average sizes of females** (Figure 3, left) in the catch from 1997-2001 compared to the early to mid 1990s is due in part to the removal of accumulated older and larger animals in the population by the fishery, but decreased growth rates of the strong 1993-1995 year-classes is also a factor. This trend has reversed in recent years as the survivors of these year-classes continued to grow and the weaker succeeding year-classes achieved larger sizes. An increasing trend in the **proportion of females** (Figure 3, left) caught during 2000-2004 occurred as males became less abundant and the 1993-1995 year-classes dominated the population and catch as females. This trend reversed in 2005-2006 as these year-classes died off and the strong 2001 year-class appeared in catches as males. **Count** (numbers of shrimp per pound, Figure 3, right) estimates provided by vessel captains increased significantly in 2005-2006 for the same reason. This indicates that many fishers had difficulty avoiding small shrimp from this year-class and maintaining counts below buyer limits to obtain the best prices. Some fishermen voluntarily switched to larger codend mesh sizes beginning in 2004, but this was ineffective in avoiding small shrimp during 2005 and 2006 as the 2001 year-class grew and dominated catches. Experienced captains have significantly lower counts, indicating that fishing skill is a factor. High counts and low prices continue to concern the fishery, however exploitation rates of the smaller sizes are at or below average, consequently, this is not a conservation concern.

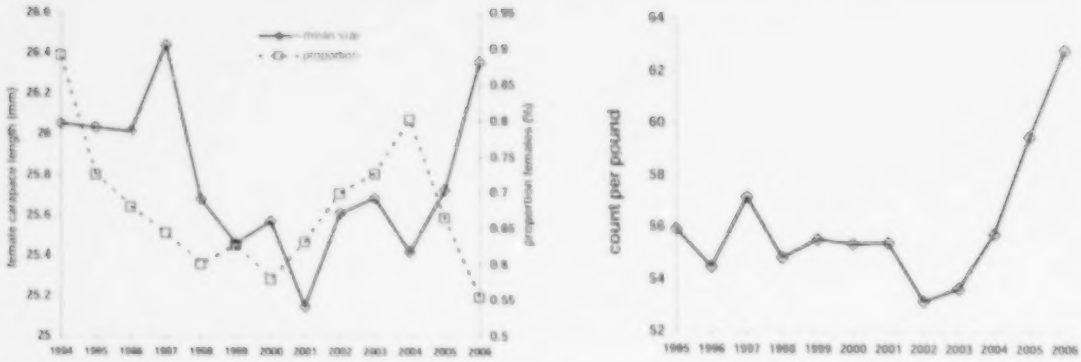


Figure 3. Mean female carapace length, proportion of females (left) and the count per pound (right) in the commercial shrimp trawl fishery.

ASSESSMENT

Stock Trends and Current Status

After a sustained long-term increase, commercial **CPUE** (Figure 4) leveled off and even decreased slightly during 2001-2005, but increased to an all time high in 2006, due to increased availability of the 2001 year-class. However, these indices probably do not reflect overall abundance changes in the short term due to changes in the spatial distribution of the resource and fishing effort and in availability to the gear.

The DFO-industry **survey index** (Figures 4, 5) decreased again in 2006, but was still the third highest of the 12 year series. Most of the biomass (60%) remains concentrated in Survey Area 14 (Misaine). The **spawning stock biomass** (female) also decreased during the last 2 years but it remains above average and is expected to remain high or increase in 2007 as the 2001 year-class changes sex.

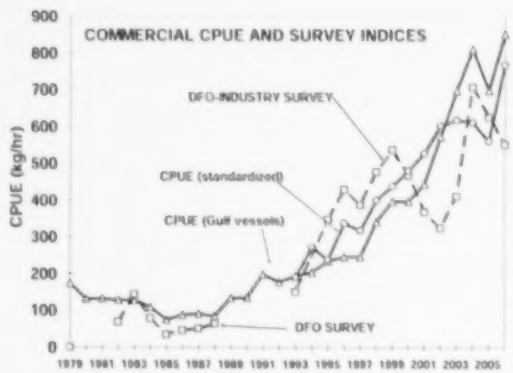


Figure 4. Commercial CPUE and survey abundance indices.

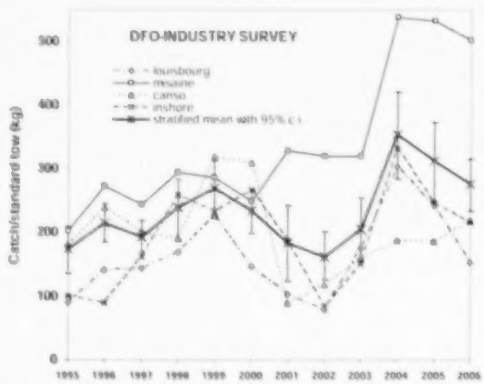


Figure 5. DFO-industry survey abundance indices by strata.

During the late 1990s, the fishery was supported by a strong group of year-classes (1993-1995), which reached the end of their life cycle in the early 2000s. Lower levels of recruitment in the mid 1990s led to a biomass decrease from 2000-2002 (Figure 5). Good recruitment mainly associated with the 2001 year-class has led to the current high biomass. This year-class

continues to be strong in most areas and currently makes up about half of the biomass, which is a concern because of the unevenly distributed size/age structure. **Age 4 shrimp** in 2006 (i.e. 2002 year-class shrimp that should begin entering the fishery as females in 2007) were not detected in the analysis and their abundance appears to be very low. This is not considered a problem because due to slow growth and delayed sex change recruits to the female population in 2007 will come from the large 2001 year-class. The **abundance of age 2 shrimp** (2004 year-class) was below average in the 2006 survey trawl. Survey trawl and belly bag catches indicate that the 2002-2005 year-classes are considerably weaker than the 2001 year-class.

Total exploitation (10%) and **female exploitation** (14%) increased again in 2006 as the TAC remained high and biomass decreased, but remained below the long term average (12 and 16%, respectively). Exploitation was more evenly distributed throughout the stock area in 2005-2006 than previously.

Decreases in average **length at sex change** (L_t) in shrimp stocks may be associated with decreased growth rates, and population downturns due to decreased population fecundity (smaller shrimp produce fewer eggs). On the Scotian Shelf, length at sex change (Figure 6) has shown a decreasing trend since 2002. **Maximum size** (L_{max}) has shown a similar decreasing trend (Figure 6) however, both indicators remain above the mean 1980s values. The 2005-2006 decrease in L_t has probably been influenced by the passage of the 2001 year-class through the population, but a continued decreasing trend in both indicators associated with environmental changes such as increasing water temperatures, would be a concern.

Regarding **ecosystem considerations**, feeding studies have shown that shrimp are important prey for many groundfish species and significant negative correlations between shrimp and groundfish abundance have been demonstrated from the Gulf of Maine to Greenland. Many groundfish stocks remain at low levels (Figure 7) on the eastern Scotian Shelf and **natural mortality** due to predation is probably below the long-term average. Since shrimp abundance remains higher than the long term average despite fishing, and because shrimp constitutes only a fraction of their diet, it seems unlikely that the fishery is impacting the recovery of groundfish species by decreasing available prey. The introduction of the Nordmøre grate in 1991 reduced juvenile groundfish by-catch and allowed the fishery to expand to its present size. Recent analysis of observer and survey data confirms that by-catch remains very low and probably has little effect on the ecosystem. However, despite low by-catch by weight, most fish caught are small and some commercial species, particularly flatfish, are caught in relatively large numbers. The impact of these removals is probably negligible but cannot be quantified because the sizes of flatfish populations are not known.

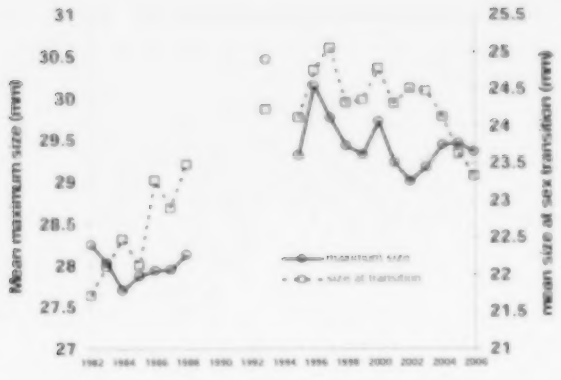


Figure 6. Changes in mean size at sex transition and maximum size.

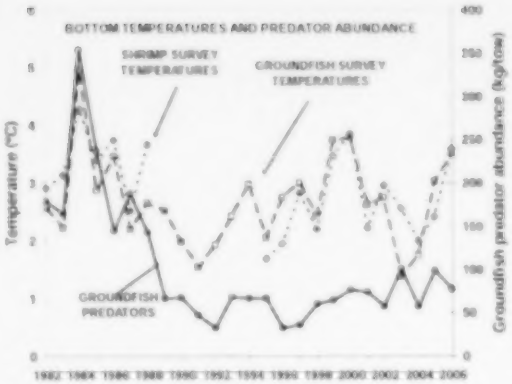


Figure 7. Bottom temperatures and predator abundance on the eastern Scotian Shelf shrimp grounds.

For some northern shrimp stocks near the southern limits of the species range, abundance is negatively correlated with water temperatures. On the Scotian Shelf, the population increase during the late 1980s may be associated with colder surface and bottom **water temperatures**. Large fluctuations in bottom water temperatures (Figure 7) may also be associated with the cyclical recruitment pattern experienced since the early 1990s (i.e. 1993-1995 and 2001 year-classes). The continued abundance of most cold water indicator species including shrimp, capelin and Greenland halibut suggests that the regime shift which led to their success is enduring. However, surface and bottom water temperatures have been increasing recently, and a continuing warming trend would be a concern for the shrimp stock.

Figure 8 provides a summary of 23 indicators related to the health of the eastern Scotian Shelf shrimp stock. Each indicator was assigned a colour for every year that there are data according to its percentile value in the series i.e. >0.66 percentile = green ● or good, 0.66-0.33 = yellow ○ or intermediate and <0.33 = red ⊖ or bad. Indicators have been grouped into stock characteristics of abundance, production, fishing effects and ecosystem. Note that indicators are not weighted in terms of their importance, and the summary given at the top of the figure was determined as an unweighted average of individual indicators.

There was considerable change in the traffic light table from last year. The summary colour changed from green to yellow, and three of the four characteristics (production, fishing impacts and ecosystem) are now yellow. The abundance characteristic and most of its component indicators remain green. The production characteristic changed from green to yellow largely because of decreases in the recruitment indicators, however, note that the low or undetectable Age 4 abundance is not considered a problem as described above. However, shrimp maximum size and size at sex change are a concern, as is the relatively low level of recruitment since 2001. The fishing impact characteristic remained yellow largely because of the high counts and the low proportion of females in the catch associated with the strong 2001 year-class. The ecosystem characteristic remained yellow because of increased temperatures. However, colour changes for ecosystem indicator species were ambivalent, with no strong signals suggesting a regime shift to one less favorable to shrimp.

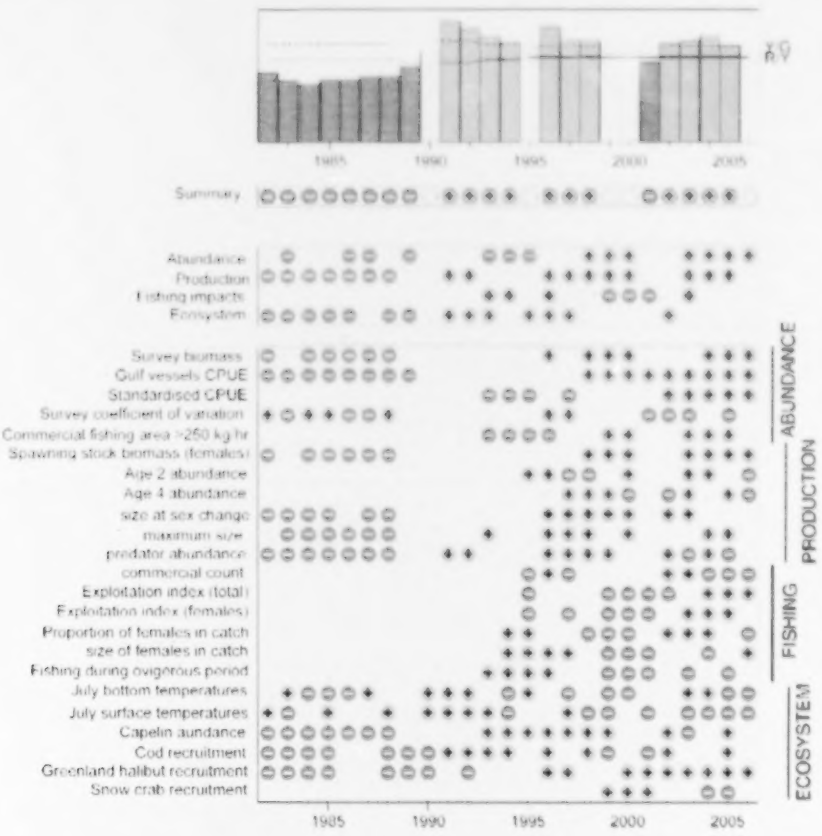


Figure 8. Traffic Light Analysis. Not all indicators in the Traffic Light table are discussed in the text. Please consult CSAS Research Document 2006/090 for a detailed description.

Sources of Uncertainty

DFO-industry shrimp survey results are associated with high variances. The accuracy of estimates can also be biased by temporal changes in availability during the survey period. Spatial analyses indicate that catch rates do not always represent overall abundance trends. There is considerable subjectivity associated with assigning modal groups to year-classes, consequently estimates of year-class strength, population numbers-at-age and projections using these analyses must be interpreted cautiously. Growth rates can decrease dramatically due to density dependence as appears to be happening with the strong 2001 year-class. Consequently, recruitment to the fishery will be delayed and spread over a longer time period. Uncertainties associated with the growth rate and sex change of this year-class preclude quantitative projections at this time. Unforeseen changes in the ecosystem e.g. predators, and the environment, e.g. temperature, together may lead to major regime shifts requiring radically different management strategies.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Industry noted the problems experienced with small shrimp, which would be from the 2001 year-class, and low prices. As well, industry representatives stated that by-catch on vessels based in New Brunswick are generally less than 1%.

CONCLUSIONS AND ADVICE

Shrimp from the strong 2001 year-class continued to grow slowly and most individuals delayed sex changes in 2006. These shrimp should begin to recruit to the fishery as females in 2007, perhaps over several years. Consequently, total and spawning stock biomass should remain high or increase in 2007. The 2002-2005 year-classes appear to be below average at this time, and biomass is expected to decrease after the 2001 year-class dies off. TAC reductions may be indicated after 2007. The 2001 year-class will not achieve maximum size for several years. However, counts in 2007 should be more favourable than the previous 2 years due to growth, even if this continues to be slower than average. With biomass expected to remain high, the high TACs of the last two years should be sustainable for at least one more year. However, it should be noted that the evenly distributed size/age classes observed at the beginning of this fishery has been replaced by a variable recruitment pattern due to exploitation, environmental influences or both, resulting in a less stable population more vulnerable to significant decreases. A continued precautionary approach, including annual assessments and a conservative harvest strategy, is indicated.

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